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Concept Note

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I. Executive Summary

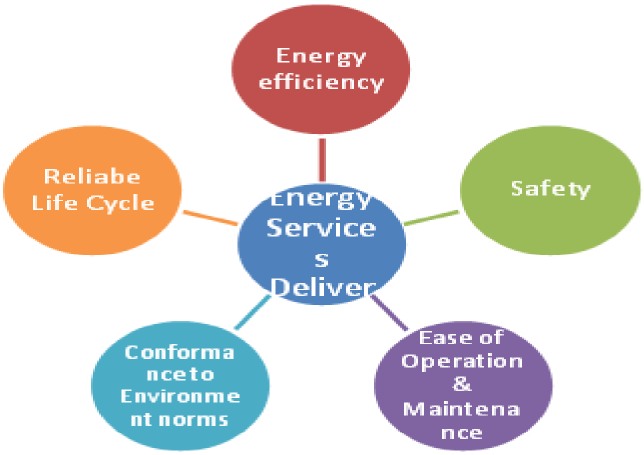
Introduction:-

MSN Labs Pvt. Ltd. is setting up and API expansion facility adjacent to existing API facility which includes addition of new blocks i.e. N,M,P,R,U,V,T and S blocks. This includes addition of equipment such as Reactors, Dryers, 200 KL ZLD, solvent recovery columns. To cater to the additional block, plant is augmenting its utility generation capacities as well.

Objective

- Towards Productivity
  - Validation of utility loads vs generation capacity for adequacy
  - Utility qualitative and quantitative parameters in line with process requirements i.e.
  - All temperature gradients for heating/cooling are achieved in desired timelines
  - All flow rates are achieved as desired
  - Lowest pressure drop within the distribution networks
  - Zero downtime steam system design
- Towards Energy Consumption (Opex)
  - CRF (>65% of recoverable) & 100% of Flash steam
  - Feed water temperature of >70^{o}C
  - Design with heat integration with condensate, flash and other sources at project stage will ensure entire water and heat recovery is optimized from day one
  - Zero Leak utility system design
- Towards Capex
  - Validating sizing of the generators and optimized distribution network
  - ±5% Accuracy for Piping and Accessories BOQs
- Towards Safety
  - Ergonomic design with strategic isolations, controls & interlocks across utilities
  - Safe routing of all discharge/vent lines within the steam & condensate system
- Towards Ease of Operations & maintenance
  - Incorporating strategic diagnostic system to facilitate monitoring and corrective actions
  - Load segregation and design to cater to fixed/variable loads enabling isolations for flexible operations
  - Modular design to enable phase wise expansions
- Towards Ease of Procurement & Site Execution

Design with detailed deliverables (Layout, Section Drawings, Detailed BOQs ensuring ease of procurement and site erection



Scope of Work:-

As per scope, Forbes Marshall has considered the following utilities for design,

Utility	Scope
Steam	Basic Engineering (Validation) + Detail Engineering
Condensate	Detail Engineering
Compressed Air for Process, Instrumentation & Breathing	Basic Engineering (Validation) + Detail Engineering
Hot Water	Basic Engineering (Validation) + Detail Engineering (Supply and return lines)
Chilled water (+5deg C)	Basic Engineering (Validation) + Detail Engineering (Supply and return lines)
Brine (-15deg C)	Basic Engineering (Validation) + Detail Engineering (Supply and return lines)
Cooling Water (RT)	Basic Engineering (Validation) + Detail Engineering (Supply and return lines)
Nitrogen	Detail Engineering –
Vacuum (General Vacuum & High Vacuum)	Detail Engineering-
Solvent & Used Solvent Lines	Detail Engineering
Effluent transfer lines from block	Detail Engineering-

Key Performance Indicator:-

- Condensate recovery factor is more than 65% of recoverable condensate and 100% flash steam recovery
- Feed water temp of >70 Deg.c
- Proper steam pressure distribution as per the process & OEM requirement
- Appropriate selection of steam trap system for proper condensate evacuation
- Zero leak steam system

Overall Plant Details:-

a) There are total 8blocks in which T,N,P,R are intermediate blocks. S block is dryer block. U,M,V are clean rooms.
b) There is one MEE and SRS block.
c) In P block 30 no. of reactors are installed, 6 are yet to installed. Out of 36, 32 are main and 4 are additional reactor.
d) There are two tank pad. Tank pad-1 for M,N,P,T blocks and Tank pad -2 is for S,U,V and QC blocks. Tank pad has solvent storage tanks having capacity of 20 And 50 KL. Exact details are to be provided by MSN.
e) There are two utility blocks 4 and 5. Block 4 has utility like +5 chilled and -15 brine, compressed air and nitrogen. Utility 4 supplies to M,N,P&T blocks.
f) Compressed air used for following
    1. Air pressing of reactors. (3 barg)
    2. Breathing air (3 barg) and instrument air (4-5barg)
    3. Air for nitrogen system. (7 barg)
    4. Common compressed air system is planned at utility block 4 which supplies to P,N,M,T blocks
    5. Common compressed air system is planned at utility block 5 which supplies to R,S,U,V blocks

    6. Separate air compressors for MEE and SRS.

g) Chilled water is used for,
    1. +5 Deg,c for secondary condensers
    2. -15 Deg.c for reactors.

h) Chilled water system will have cold and hot well.

i) Portable water system will be in utility block 4, 1st floor. This water is used for N, P,T,R&S blocks. Supply and installation of potable water system and entire distribution piping till equipment is under OEM scope.

j) Cooling towers for chillers will be placed in terrace of utility block 4.

k) Cooling tower for MEE and SRS are placed near MEE/SRS only. Stripper and ATFD of MEE will have one cooling tower and MEE will have separate.

l) Following utilities will be used in reactors,
    1. Steam (3 bar g)
    2. Hot water (90 Degc. Max)
    3. -15 Deg.c brine
    4. Compressed air
    5. RT water (Cooling water)

m) Reactors will have supply and return headers with manual operation. There are two types of reactors, SS and GL reactors.

n) Reactors filtering system will be of centrifuge or ANFD or nutch filter (SSPNF) or leaf filters. After filtration ML will be transferred to tank pads.

o) Cooling towers for each block
    1. One working and one std. by for reactors
    2. One working and one std. by for primary condensers
    3. One working and one std. by for vacuum system.

p) Vacuum system for each block,
    1. For P,R,N and T blocks
        - 4 no. high vacuum system – group of reactors can have a separate pump and line
        - 4 no. vacuum pump at plant for dry vacuum (High vacuum)
        - Both above are for distillation operation
        - 4 no. general vacuum system near cooling tower for transferring organic layering and ML Transferring
    2. For remaining block no. of vacuum pumps will be less (Details will be provided by MSN)

q) Utility block 5 will have
    1. +5 Degc. & -15 Deg.c Chilled water
    2. These utility will be supplied to U,V,S&R block
    3. Purified water system of Praj will be placed in 1st floor
    4. Supply and installation of purified water system and entire distribution piping till equipment is under OEM scope.

r) Hot water System for reactors:-
    1. 6 KL hot water system will be placed outside of the plant on both side.
    2. 2 no. for each block
    3. Hot water system will have heat exchanger provided with steam system

s) Hot water System for ANFD:-
    1. Each ANFD will have separate hot water system. In case two ANFD are near by, common system can be planed. (MSN will share the final details of hot water tanks)
    2. Vaccum also to be provided for ANFD

t) Nitrogen System:-

1. Common system is planned at utility block 4
2. This is used for reactor & Centrifuge blanketing (pressure of 3 barg) and ANFD/SSPNF/SSLF/ML transferring.
3. Solvent Pads

u) Steam System:-

1. Currently steam will be taken from existing 10 TPH boiler.
2. Later on interconnection will be provided between new boiler and 10 TPH boiler.
3. New boiler will be of 16 TPH at 10.5 barg. (Coal fired)
4. Steam is majorly used in Hot water systems, tray dryers, MEE and SRS, sometimes used in reactors for cleaning purposes or

Process Description:-

1. Based on the discussion steam is required for the product having Toluene as base solvent having boiling point of 110 Deg.c. (Steam pressure used is 3 barg)
2. For rest of the solvents having boiling point lower than 100 Deg.c Hot water is used as heating media for distillation process in reactors.
3. Hot water is generated by using steam at 3 bar pressure in hot water generation tanks having shell and tube heat exchanger.
4. RT water is used in primary condenser in which 70% of vapours are condensed and 30% vapours are condensed in secondary condenser by circulating +5 Deg.c chilled water.
5. In reactors jackets -15 Deg.c brine is used only in case of product mix having exothermic reaction. Here initially reaction mass is cooled around -10 Deg.c by circulating brine in reactor jacket and then solvent is added for reaction in reactor.

Process Utilities:-

- Steam & condensate recovery
- Chilled Water Supply and Return
- Cooling Water Supply and return
- Hot water Supply and Return
- Compressed air
- Brine solution supply and Return

II. Design Basis:-

Design Basis for steam & condensate

- Multi Utility Reactors- 36 No. (1KL=4no., 4KL=6no., 5KL=3no., 6KL=6no., 6.3KL=4no., 8KL=7no., 10KL=6no.,)
- Hot water Tanks – 6KL=2no., 1KL=4no.
- Temperature requirement in hot water tank is 80-85 deg.
- The entire heating requirement in reactor is catered by hot water. Steam may require only while cleaning the reactor or in process having solvent whose boiling point is above 100 Deg.c. (But all the reactions are carried out in vacuum hence no steam requirement for reactor)
- Velocity for Pipe design
  1. Saturated steam – 25 to 30 m/s
  2. Flash steam – 15 m/s
- Pressure drop for condensate line = 0.8 mbar per meter
- Pressure reducing station needs to be installed for supply of optimum steam pressure to process as per temp requirement

Steam Consumption & Loading details:-

- All the steam consuming equipments and their consumption is as below.

Sr. No	Equipment	Capacity	Qty.	Steam pressure	Steam Consumption Kg/hr.
1	Hot water tank	6 KL	2	3.5 bar	1257
2	Hot water tank	1KL	4	3.5 bar	116
3	Reactor	1 KL	4	3.5 bar	46
4	Reactor	4 KL	6	3.5 bar	183
5	Reactor	5 KL	3	3.5 bar	228
6	Reactor	6 KL	6	3.5 bar	274
7	Reactor	6.3 KL	4	3.5 bar	288
8	Reactor	8 KL	7	3.5 bar	365
9	Reactor	10 KL	6	3.5 bar	457

- Steam line size and PRS selection is done considering all hot water tanks are in running condition along with two no. of 10 KL reactor are in heating mode with solvent having boiling point more than 100 Deg.c i.e. peak steam load will be around 3.8 TPH. The average load is consider for all hot water system are in running condition i.e. average load will be around 2.9 TPH
- The branch header for both side of reactor is designed for steam load of 2 TPH (i.e. 100 NB each) and main header and main header is designed for 3.8 TPH of steam flow (i.e.150 NB)

Good Engineering Practices:-

- Air vents are recommended on headers, highest points and on remote ends.
- Expansion loop with a drain point and TD trap after every 30 m and a drain point with TD trap are recommended before every rising pipe.

Trap Size:-

- Two orifice float trap selected for equipments with condensate load of maximum 3300 kg/hr. (Initially to handle start up load at 6 KL hot water system)
- 25 NB ball single orifice float trap module selected for equipments with condensate load of maximum 1030 kg/hr.
- 20 NB ball two orifice float trap module selected for equipments with condensate load of maximum 700 kg/hr.

- Condensate from all hot water tanks flashed at 0.5 bar g pressure and the flash steam is sent back to all hot water tanks and low pressure condensate are returned to the feed water tank. This enables a condensate recovery factor of above 65% for indirect heating applications.
- The condensate recovery pump has design to pumping maximum capacity of condensate with motive steam pressure of 2 & 3 bar g considering back pressure of 1 bar

- Please refer the below line size chart for future reference.

Particulars	Steam Load Kg/hr.	velocity m/s	Steam Pressure bar	Line Size NB
Main line size to Block	4000	25-30 m/s	10.5	100
Branch Tapping	2000	25-30 m/s	3.5	100
PRS	4000	25-30 m/s	10.5 to 3.5	100x150
Condensate recovery pump	3750			50
Flash vessle	250	15 m/s	0.5	200
Steam Flow meter	4000		10.5	80

Challenges Faced	Strategy Used
Difficulty in monitoring steam consumption of Block	A Steam flow meter is installed at block inlet to get the steam consumption trends and abnormality if any
	Benefits - Energy Efficiency
All reactor and hot water tank requires steam at pressure of 3.5 bar but boiler supply pressure is 10.5 bar	One common PRS station of 10.5 to 3.5 bar is installed and steam supply is controlled at each hot water tanks by installing temp ctrl valve to have better temp control.
A header needed to distribute LP steam to hot water tanks and reactors but available area is restraint	The PRS station is installed at ground floor outside of the block and from that two separate header are laid for two sides of the block
	Benefits - Easy of operation and maintenance

WATER UTILITY

Data Given

- Cooling water (RT Water), Chilled Water (+5 Deg.c Water), Brine (-15 Deg.c) and hot water are needed for all reactor jacket and reactor condenser for heating and cooling purposes.

Hot water for reactor Jacket

Considerations:-

- Basically hot water is used in rector jacket for solvent heating purpose under vacuum condition. Mostly solvents are having boiling point less than 100 Deg.c hence heating and distillation can be carried out by using hot water in jacket.
- The heat load is worked out based on 1KL capacity basis and same is used for calculating peak loads for rest of the reactors having capacity up to 12 KL.
- The solvent content in reactor is 60% of its capacity.
- Initially solvent is heated up to its boiling point and then distillation process starts after adding of the rest of the reacting material in reactor. (for sizing purpose we have consider the heating and evaporation is at atmospheric pressure)
- Based on the boiling points and latent heat of the solvent, max boiling point temp and max latent heat capacity solvent is compared and peak load for hot water is worked out. For example toluene has max boiling point and Methanol has max latent capacity.
- Here we also consider that out of total evaporation qty. around 15% will happen in 1st hr. and heating time up to boiling of solvent is 80-90 min.
- Velocity for Pipe design
  1. Hot water – 2 to 3 m/s
  2. Delta temp. – 10 Deg.c

Heat load calculation Basis:-

Particulars\Types of solvents	Toluene	Methanol
Reactor Capacity KL	1	1
Reactor Loading Capacity KL 60% of total volume	0.6	0.6
Density of Solvent Kg/m3	866	791
Specific Heat of solvent Kcal/Kg deg.c	0.325	0.605
Boiling point of solvent At ATM Deg.c	110.6	64.7
Latent Heat of solvent Kcal/kg	88.17	263
Initial Temp Deg.c	30	30
Final Temp Deg.c	110.6	64.7
Solvent mass Lit.	519.6	474.6
Heat requirement for Solvent up to Boiling point Kcal	13610.9	9963.5
Heat requirement for vessel heating Kcal	20633.6	8883.2
Radiation loss from Vessel Kcal	684.8	376.9
Total heat requirement for mass heating Kcal	**34929.4**	**19223.6**
Time for Heating in min for Hot water	90	90
Total Heat Requirement Kcal/hr.	23286.2	12815.7
Hot water requirement Considering DT of 10 Deg.c	3492.9	1922.3

Particulars\Types of solvents	Toluene	Methanol
Hot water flow rate for mass heating Kg/hr.	**2328.6**	**1281.5**
Heat for Distillation Kcal	45813.1	124819.8
Time for distillation min	480	480
Heat rate for distillation per hr.	5726.6415	15602.475
Considering 15% distillation in 1st hr. Hot water flow Kg/hr.	**687.19698**	**1872.297**

- From Above table for sizing purpose we have considered the toluene solvent having max hot water flow requirement for heating requirement.
- Below Table shows hot water flow rate requirement for each reactor.

Capacity	No. of reactors	Peak Hot water Flow rate Kg/hr.
10	6	23286
8	7	18629
6.3	4	14670
6	6	13972
5	3	11643
4	6	9315
1	4	2329
Total	36	93844

- For main header sizing for both side of the plant we have considered around 25-28% of reactor are in operation at time. (Reactors are equally installed on both side of plant i.e. 18 on each side)
- Based on that 65 m3/hr is the peak flow rate for each branch. Considering the same 125 NB distribution header is sufficient to cater the peak load.
- The two no. of hot water system are placed in the block one on each side.

Good Engineering Practices

- For ease of monitoring purpose we suggest to have temp and pressure gauges on each reactor inlet and out let hot header.
- For ease of operation and maintenance purpose we have installed inlet and outlet isolation valves along with non-return valve on return line and strainer on hot water supply line.
- For safety point of view we have recommended to installed VFD on hot water supply pump so that when heat loads are on lower side then pump flow rate will be cut down to min level and main hot water supply header will not get pressurized and. Also supply and return header connected with valve which should be crack open so that header will not get pressurized un necessary.
- For having better heat transfer efficiency we have installed air eliminator at header dead end to remove entrapped air if any from supply header. As air is act as insulator for heat transfer.

Cooling water (RT water) for Jacket Cooling

Considerations:-

- Basically RT water is used in rector jacket for solvent cooling purpose under vacuum condition from respective solvent boiling point to room temp.
- The heat load is worked out based on 1KL capacity basis and same is used for calculating peak loads for rest of the reactors having capacity up to 12 KL.
- The solvent content in reactor is 60% of its capacity.
- Initially solvent is heated up to its boiling point then reaction is completed adding of the rest of the reacting material in reactor. Once all process is done whole mass is cooled down to room temp. (for sizing purpose we have consider the heating and cooling is at atmospheric pressure)
- Based on the boiling points of the solvent, max boiling point temp solvent is considered and peak load for RT water is worked out. For example toluene has max boiling point.
- Here we also consider that the total cooling time up to room temp is 3hr
- Velocity for Pipe design
  1. Cooling water – 2 to 3 m/s
  2. Delta temp. of water – 5 Deg.c

Heat load calculation Basis:-

Particulars\Types of solvents	Toluene
Reactor Capacity KL	1
Reactor Loading Capacity KL 60% of total volume	0.6
Density of Solvent Kg/m3	866
Specific Heat of solvent Kcal/Kg Deg.c	0.325
Boiling point of solvent At ATM Deg.c	110.6
Latent Heat of solvent Kcal/kg	88.17
Initial Temp Deg.c	110.6
Final Temp Deg.c	30
Solvent mass Lit.	519.6
Heat requirement for cooling of Solvent from Boiling point to atm temp.Kcal	13610.9
Heat requirement for vessel cooling Kcal	20633.6
Radiation loss from Vessel Kcal	684.8
Total heat requirement for mass cooling Kcal	**34929.4**
Time for Reactor cooling min	180
RT water for Reactor Jacket Kg/hr.	**2328.6**

- From Above table for sizing purpose we have considered the toluene solvent having max RT water flow requirement for cooling requirement.
- Below Table shows hot water flow rate requirement for each reactor.

Capacity	No. of reactors	Peak RT water Flow rate Kg/hr.
10	6	23286
8	7	18629
6.3	4	14670

6	6	13972
5	3	11643
4	6	9315
1	4	2329
Total	36	93844

- For main header sizing for both side of the plant we have considered around 25-28% of reactor are in operation at time. (Reactors are equally installed on both side of plant i.e. 18 on each side)
- Based on that 80 m3/hr is the peak flow rate for each branch. Considering the same 150 NB distribution header is sufficient to cater the peak load. Main Header from utility supply side will be of 200 NB which will cater the total water load of 155 m3/hr.
- The two no. of cooling tower system are placed in the utility block one running and one stand by.

Good Engineering Practices

- For ease of monitoring purpose we suggest to have temp and pressure gauges on each reactor inlet and out let of header. Also we have suggested having water from meter on main supply header so as to monitor total TR utilized in the block.
- For ease of operation and maintenance purpose we have installed inlet and outlet isolation valves along with non-return valve on return line and strainer on cooling water supply line.
- For safety point of view we have recommended to installed VFD on cooling water supply pump so that when heat loads are on lower side, then pump flow rate will be cut down to min level and main hot water supply header will not get pressurized and. Also supply and return header connected with valve which should be crack open so that header will not get pressurized un necessary.
- For having better heat transfer efficiency we have installed air eliminator at header dead end to remove entrapped air if any from supply header. As air is act as insulator for heat transfer it should be removed from piping system.

Cooling water (RT water) for Primary Condenser Cooling

Considerations:-

- RT water is also used in rector primary condenser for solvent cooling purpose under vacuum condition.
- The heat load is worked out based on 1KL capacity basis and same is used for calculating peak loads for rest of the reactors having capacity up to 12 KL.
- It is considered that out of total solvent evaporated 70% is condensed in primary condenser and 30% will condense in secondary condenser.
- Out of this 70% of solvent vapor load 30% will condense in initial 1st hr. of process. The outlet of condensed solvent is at room temp to recover.
- The solvent content in reactor is 60% of its capacity.

- Based on the latent heat of the solvent, max latent heat having solvent is considered and peak load for RT water is worked out. For example Methanol has max latent heat content among the solvents used in this block process.
- Velocity for Pipe design
  1. Cooling water – 2 to 3 m/s
  2. Delta temp. of water – 5 Deg.c

Heat load calculation Basis:-

Perticulars\Types of solvents	Methanol
Reactor Capacity KL	1
Reactor Loading Capacity KL 60% of total volume	0.6
Density of Solvent Kg/m3	791
Specific Heat of solvent Kcal/Kg deg.c	0.605
Boiling point of solvent At ATM Deg.c	64.7
Latent Heat of solvent Kcal/kg	263
Initial Temp Deg.c	30
Final Temp Deg.c	64.7
Solvent mass Lit.	474.6
Total vapour load for primary condenser 70% of total vapour load	332.22
Total vapour load for Secondary condenser 30 % of total vapour load	142.38
RT water for Primary Condenser considering 30% vapour condensed 1 st hr. in Kg/hr.	**5660.8**

- From Above table for sizing purpose we have considered the Methanol solvent having max RT water flow requirement for cooling requirement.
- Below Table shows hot water flow rate requirement for each reactor.

Capacity	No. of reactors	Peak RT water Flow rate Kg/hr.
10	6	57962
8	7	46370
6.3	4	36516
6	6	34777
5	3	28981
4	6	23185
1	4	5661
Total	36	233453

- For main header sizing for both side of the plant we have considered around 25-28% of reactor are in operation at time. (Reactors are equally installed on both side of plant i.e. 18 on each side)

- Based on that 245 m3/hr is the peak flow rate for each branch. Considering the same 200 NB distribution header is sufficient to cater the peak load. Main Header from utility supply side will be of 250 NB which will cater the total water load of 386 m3/hr.
- The two no. of cooling tower system are placed in the utility block one running and one stand by.

Good Engineering Practices

- For ease of monitoring purpose we suggest to have temp and pressure gauges on each reactor inlet and out let of header. Also we have suggested having water from meter on main supply header so as to monitor total TR utilized in the block.
- For ease of operation and maintenance purpose we have installed inlet and outlet isolation valves along with non-return valve on return line and strainer on cooling water supply line.
- For safety point of view we have recommended to installed VFD on cooling water supply pump so that when heat loads are on lower side, then pump flow rate will be cut down to min level and main hot water supply header will not get pressurized and. Also supply and return header connected with valve which should be crack open so that header will not get pressurized un necessary.
- For having better heat transfer efficiency we have installed air eliminator at header dead end to remove entrapped air if any from supply header. As air is act as insulator for heat transfer it should be removed from piping system.

Chilled water (+5 Deg.c water) for Secondary Condenser Cooling

Considerations:-

- Chilled water is also used in rector secondary condenser for solvent cooling purpose under vacuum condition.
- The heat load is worked out based on 1KL capacity basis and same is used for calculating peak loads for rest of the reactors having capacity up to 12 KL.
- It is considered that out of total solvent evaporated 70% is condensed in primary condenser and 30% will condense in secondary condenser.
- Out of this 30% of solvent vapor load 30% will condense in initial 1st hr. of process. The outlet of condensed solvent is at room temp to recover.
- The solvent content in reactor is 60% of its capacity.
- Based on the latent heat of the solvent, max latent heat having solvent is considered and peak load for chilled water is worked out. For example Methanol has max latent heat content among the solvents used in this block process.
- Velocity for Pipe design

  3. Chilled water – 2 to 3 m/s
  4. Delta temp. of water – 5 Deg.c

Heat load calculation Basis:-

Particulars\Types of solvents	Methanol
Reactor Capacity KL	1
Reactor Loading Capacity KL 60% of total volume	0.6

Density of Solvent Kg/m3	791
Specific Heat of solvent Kcal/Kg deg.c	0.605
Boiling point of solvent At ATM Deg.c	64.7
Latent Heat of solvent Kcal/kg	263
Initial Temp Deg.c	30
Final Temp Deg.c	64.7
Solvent mass Lit.	474.6
Total vapour load for primary condenser 70% of total vapour load	332.22
Total vapour load for secondary condenser 30 % of total vapour load	142.38
+5' Degc water for Secondary Condenser considering 30% vapour condensed 1 st hr. in Kg/hr.	**2426.0**

- From Above table for sizing purpose we have considered the Methanol solvent having max chilled water flow requirement for cooling requirement.
- Below Table shows hot water flow rate requirement for each reactor.

Capacity	No. of reactors	Peak chilled water Flow rate Kg/hr.
10	6	24841
8	7	19873
6.3	4	15650
6	6	14905
5	3	12421
4	6	9936
1	4	2426
Total	36	100051

- For main header sizing for both side of the plant we have considered around 25-28% of reactor are in operation at time. (Reactors are equally installed on both side of plant i.e. 18 on each side)
- Based on that 105 m3/hr is the peak flow rate for each branch. Considering the same 125 NB distribution header is sufficient to cater the peak load. Main Header from utility supply side will be of 200 NB which will cater the total water load of 165 m3/hr.
- There is common chilled water system is placed in the utility block having one running and one stand by pump for dedicated block.

Good Engineering Practices

- For ease of monitoring purpose we suggest to have temp and pressure gauges on each reactor inlet and out let of header. Also we have suggested having water from meter on main supply header so as to monitor total TR utilized in the block

- For ease of operation and maintenance purpose we have installed inlet and outlet isolation valves along with non-return valve on return line and strainer on cooling water supply line.
- For safety point of view we have recommended to installed VFD on cooling water supply pump so that when heat loads are on lower side, then pump flow rate will be cut down to min level and main hot water supply header will not get pressurized and. Also supply and return header connected with valve which should be crack open so that header will not get pressurized un necessary.
- For having better heat transfer efficiency we have installed air eliminator at header dead end to remove entrapped air if any from supply header. As air is act as insulator for heat transfer it should be removed from piping system.

Brine Solution (-15 Deg.c) For Reactor Jacket:-

Considerations:-

- Basically Brine solution is used in rector jacket for solvent cooling purpose for some exothermic reaction to be carried out. In this case initially solvent is cooled down up to -10 Deg.c and the reaction mass is added. This is to control temp shoot up during exothermic reaction.
- The heat load is worked out based on 1KL capacity basis and same is used for calculating peak loads for rest of the reactors having capacity up to 12 KL.
- The solvent content in reactor is 60% of its capacity.
- Based on the specific heat of the solvent, max specific heat content solvent is considered and peak load for Brine solution is worked out. For example IPA has max specific heat among the solvent which is used.
- Here we also consider that the total cooling time is 3hr
- Velocity for Pipe design
  1. Brine Solution – 2 to 3 m/s
  2. Delta temp. of solution – 5 Deg.c

Heat load calculation Basis:-

Particulars\Types of solvents	IPA
Reactor Capacity KL	1
Reactor Loading Capacity KL 60% of total volume	0.6
Density of Solvent Kg/m3	785
Specific Heat of solvent Kcal/Kg deg.c	0.67
Boiling point of solvent At ATM Deg.c	82.5
Latent Heat of solvent Kcal/kg	159.35
Initial Temp Deg.c	40
Final Temp Deg.c	-10
Solvent mass Lit.	471
Heat load for Reactor jacket chilling with Brine -15 Deg.c	34294.2
Chilling time for reactor min	180
Chilling load kcal/hr.	11431.4
Brine flow rate for reactor jacket Kg/hr.	**2635.178**

- From Above table for sizing purpose we have considered the IPA solvent having max Brine Solution flow requirement for cooling purpose.
- Below Table shows hot water flow rate requirement for each reactor.

Capacity	No. of reactors	Peak Brine Solution Flow rate Kg/hr.
10	6	26352
8	7	21081
6.3	4	16602
6	6	15811
5	3	13176
4	6	10541
1	4	2635
Total	36	106198

- For main header sizing for both side of the plant we have considered around 25-28% of reactor are in operation at time. (Reactors are equally installed on both side of plant i.e. 18 on each side)
- Based on that 111 m3/hr is the peak flow rate for each branch. Considering the same 125 NB distribution header is sufficient to cater the peak load. Main Header from utility supply side will be of 200 NB which will cater the total water load of 175 m3/hr.
- There is common brine system is placed in the utility block having one running and one stand by pump for dedicated block.

Good Engineering Practices

- For ease of monitoring purpose we suggest to have temp and pressure gauges on each reactor inlet and out let of header. Also we have suggested having water from meter on main supply header so as to monitor total TR utilized in the block
- For ease of operation and maintenance purpose we have installed inlet and outlet isolation valves along with non-return valve on return line and strainer on brine supply line.
- For safety point of view we have recommended to installed VFD on brine supply pump so that when heat loads are on lower side, then pump flow rate will be cut down to min level and main hot water supply header will not get pressurized and. Also supply and return header connected with valve which should be crack open so that header will not get pressurized un necessary.
- For having better heat transfer efficiency we have installed air eliminator at header dead end to remove entrapped air if any from supply header. As air is act as insulator for heat transfer it should be removed from piping system.

Compressed air for Reactor Flushing

Design Basis for compressed air for Reactor flushing.

- Design pressure – 4 bar g.
- The compressed air is used to flush the utility from reactor jacket after changeover of the utility.
- Present compressed air requirement is for 103 CFM. This demand is calculated considering 40% of machine is in flushing mode
- The compressed air header and supply line to plant is designed for 103 CFM,
- One 20 NB tapings are taken from this line for each reactor header. Ring main design enables uniform pressure availability at each user point.
- Moisture separator and drain points at strategic locations ensure dry air at user points.

Given Data:-

Air Flow rate for 10 KL reactor jacket flushing	Qty.	Units
Volume of coil	0.40	m3
No. of reactors	36	No.
Total Volume	14.46	m3
Air pressure required	**4**	**bar**
Considering diversity of 40%	**5.78**	**M3**
Volume of Air required	**152**	**CFM**
Line Size for main header	**50**	**NB**
Line size for individual header	**20**	**NB**

Good Engineering Practices

- For ease of monitoring purpose we suggest to have pressure gauges on header. Also we have suggested having air flow meter on main supply header so as to monitor total air utilized in the block
- For ease of operation and maintenance purpose we have installed inlet isolation valves supply line. Moisture separators are installed on main line to have moisture free air supply at user end.
- For Energy efficiency point of view we have recommended to installed VFD on air compressor which lowers the power requirement based on low air loading at user end. Also we recommend installing pressure reducing valves on supply air lines to have optimum air supply at user point.
- For having better heat transfer efficiency we have installed air eliminator at header dead end to remove entrapped air if any from supply header. As air is act as insulator for heat transfer it should be removed from piping system.